

CLAIMS

1. An anode for electrowinning aluminium from alumina dissolved in a molten electrolyte, said anode comprising an electrically conductive substrate that is covered with an applied electrochemically active coating, said coating comprising a layer that contains predominantly cobalt oxide CoO.
2. The anode of claim 1, wherein the CoO-containing layer is a layer of sintered particles.
3. The anode of claim 1, wherein the CoO-containing layer is an integral oxide layer on an applied Co-containing metallic layer of the coating.
4. The anode of any preceding claim, which comprises an oxygen barrier layer between the CoO-containing layer and the electrically conductive substrate.
5. The anode of claim 4, wherein the oxygen barrier layer contains at least one metal selected from nickel, copper, tungsten, molybdenum, tantalum, niobium and chromium, or an oxide thereof.
6. The anode of claim 5, wherein the oxygen barrier layer further contains cobalt.
7. The anode of claim 6, wherein the oxygen barrier layer is a cobalt alloy containing at least one metal selected from nickel, tungsten, molybdenum, tantalum and niobium.
8. The anode of claim 7, wherein the cobalt alloy contains:
 - at least one of nickel, tungsten, molybdenum, tantalum and niobium in a total amount of 5 to 30 wt%, in particular 10-20 wt%; and
 - one or more further elements and compounds in a total amount of up to 5 wt%, the balance being cobalt.
9. The anode of claim 8, containing as said further elements at least one of aluminium, silicon and manganese.

10. The anode of any one of claims 4 to 9, wherein the CoO-containing layer is integral with the oxygen barrier layer.
11. The anode of any one of claims 4 to 9, wherein the
5 oxygen barrier layer is integral with the electrically conductive substrate.
12. The anode of any one of claims 4 to 9, wherein the oxygen barrier layer and the CoO-containing layer, or precursors thereof, are distinct applied layers.
- 10 13. The anode of claim 3, or claim 11 or 12 when depending on claim 3, wherein the Co-containing metallic layer contains cobalt in an amount of at least 95 wt%, in particular more than 97 wt% or 99 wt%.
14. The anode of any one of claims 3 to 13, wherein the
15 Co-containing metallic layer contains at least one additive selected from silicon, manganese, nickel, niobium, tantalum and aluminium in a total amount of 0.1 to 2 wt%.
15. The anode of any preceding claim, wherein the
20 electrically conductive substrate comprises at least one metal selected from chromium, cobalt, hafnium, iron, nickel, copper, platinum, silicon, tungsten, molybdenum, tantalum, niobium, titanium, tungsten, vanadium, yttrium and zirconium, or a compound thereof, in particular an
25 oxide, or a combination thereof.
16. The anode of claim 15, wherein the electrically conductive substrate has an outer part made of cobalt or a cobalt-rich alloy to which the coating is applied.
17. The anode of claim 16, wherein the outer part is
30 made of a cobalt-rich alloy containing at least one of tungsten, molybdenum, tantalum and niobium, said cobalt alloy containing in particular:
- at least one of nickel, tungsten, molybdenum, tantalum and niobium in a total amount of 5 to 30 wt%, in
35 particular 10-20 wt%; and
 - one or more further elements and compounds in a total amount of up to 5 wt%,
the balance being cobalt.

18. The anode of any preceding claim, wherein the electrically conductive substrate contains at least one oxidation-resistant metal, in particular a metal selected from nickel, cobalt, chromium and niobium.
- 5 19. The anode of claim 18, wherein the electrically conductive substrate consists essentially of at least one oxidation-resistant metal.
20. The anode of any preceding claim, wherein the CoO-containing layer has an open porosity of up to 12%, in
10 particular up to 7%.
21. The anode of any preceding claim, wherein the CoO-containing layer has a porosity with an average pore size below 7 micron, in particular below 4 micron.
22. The anode of any preceding claim, wherein the CoO-
15 containing layer contains cobalt oxide CoO in an amount of at least 80 wt%, in particular more than 90 wt% or 95 wt%.
23. The anode of any preceding claim, wherein the CoO-containing layer is substantially free of Co_2O_3 and
20 substantially free of Co_3O_4 .
24. The anode of any preceding claim, wherein the CoO-containing layer is electrochemically active for the oxidation of oxygen ions and is uncovered or is covered with an electrolyte-pervious layer.
- 25 25. The anode of any one of claims 1 to 23, wherein the CoO-containing layer is covered with an applied protective layer, in particular an applied oxide layer.
26. The anode of claim 25, wherein the applied protective layer contains cobalt oxide.
- 30 27. The anode of claim 25 or 26, wherein the applied protective layer contains iron oxide.
28. The anode of claim 27, wherein the applied protective layer contains oxides of cobalt and of iron, in particular cobalt ferrite.

29. The anode of any one of claims 25 to 28, wherein the applied protective layer contains a cerium compound, in particular cerium oxyfluoride.

5 30. The anode of any one of claims 25 to 29, wherein the applied protective layer is electrochemically active for the oxidation of oxygen ions and is uncovered or is covered with an electrolyte pervious-layer.

10 31. The anode of any preceding claim, which has an electrochemically active surface that contains at least one dopant, in particular at least one dopant selected from iridium, palladium, platinum, rhodium, ruthenium, silicon, tungsten, molybdenum, tantalum, niobium, tin or zinc metals, Mischmetal, metals of the Lanthanide series, as metals and compounds, in particular oxides, and
15 mixtures thereof.

32. The anode of claim 31, wherein the electrochemically active surface is made of an active material containing the dopant(s) in a total amount of 0.1 to 5 wt%, in particular 1 to 4 wt%.

20 33. A method of manufacturing an anode as defined in any preceding claim, comprising:
- providing an electrically conductive anode substrate;
and
- forming an electrochemically active coating on the
25 substrate by applying one or more layers onto the substrate, one of which contains predominantly cobalt oxide CoO.

30 34. The method of claim 33, wherein the CoO-containing layer is formed by applying a layer of particulate CoO to the anode and sintering.

35. The method of claim 34, wherein the CoO-containing layer is applied as a slurry, in particular a colloidal and/or polymeric slurry, and then heat treated.

36. The method of claim 33, wherein the CoO-containing
35 layer is formed by applying a Co-containing metallic layer to the anode and subjecting the applied metallic layer to an oxidation treatment to form said CoO-containing layer on said metallic layer, said CoO-containing layer being integral with said metallic layer.

37. The method of claim 36, wherein the oxidation treatment is carried out in an oxygen containing atmosphere, such as air.

38. The method of claim 36 or 37, wherein the oxidation
5 treatment is carried out at a treatment temperature above 895°C or 920°C, preferably above 940°C, in particular within the range 950°C to 1050°C.

39. The method of claim 38, wherein the Co-containing
10 metallic layer is heated from room temperature to said treatment temperature at a rate of at least 300°C/hour, in particular at least 450°C/hour, for example by being placed in an environment, in particular in an oven, that is preheated to said treatment temperature.

40. The method of claims 37 to 39, wherein the oxidation
15 treatment at said treatment temperature is carried out for more than 8 or 12 hours, in particular from 16 to 48 hours.

41. The method of any one of claims 35 to 40, wherein
20 the Co-containing metallic layer is further oxidised during use.

42. A cell for the electrowinning of aluminium from alumina dissolved in a molten electrolyte, in particular a fluoride-containing electrolyte, which cell comprises an anode as defined in any one of claims 1 to 32.

25 43. The cell of claim 42, wherein said anode is in contact with a molten electrolyte of the cell, the electrolyte being at a temperature below 960°C, in particular in the range from 910° to 940°C.

30 44. A method of electrowinning aluminium in a cell as defined in claim 42 or 43, said method comprising passing an electrolysis current via the anode through the electrolyte to produce oxygen on the anode and aluminium cathodically by electrolysis the dissolved alumina contained in the electrolyte.

35 45. The method of claim 44, wherein oxygen ions are oxidised on the anode's CoO-containing layer.

46. The method of claim 44 or 45, wherein oxygen ions are oxidised on an active layer applied to the anode's

CoO-containing layer that inhibits oxidation and/or corrosion of the anode's substrate.

- 5 47. A component of a cell for the electrowinning of aluminium, in particular an anode, an anode stem, a sidewall or a cell cover, said component comprising a substrate that is covered with an applied coating, said coating comprising a layer that contains predominantly cobalt oxide CoO.